



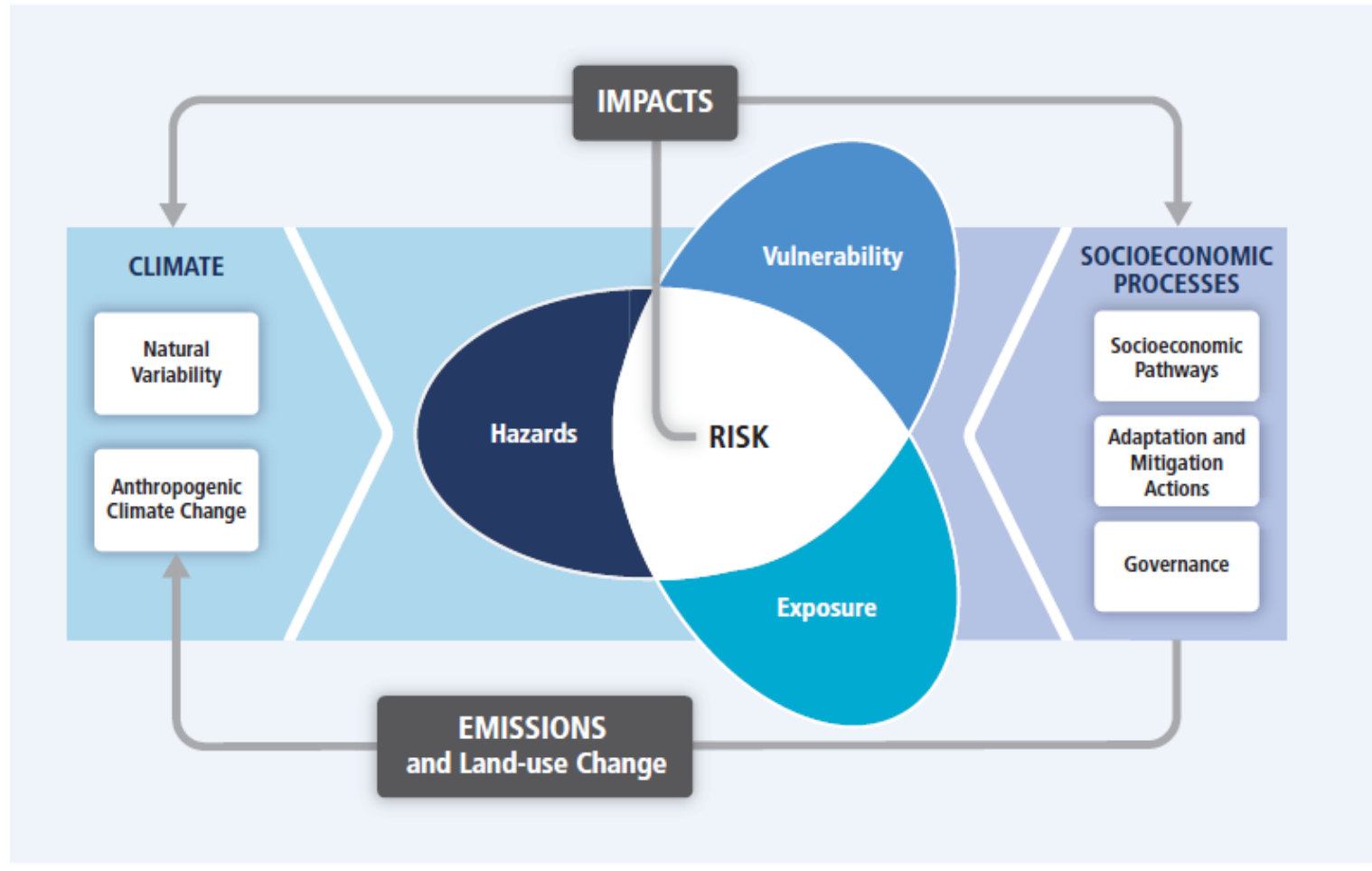
NOAA
FISHERIES

Strategies for developing climate-ready commercial fisheries in northeast Pacific ecosystems

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Climate Change Assessment (IPCC - WGII Summary for Policy Makers)



Projected Average Annual Surface Temperature (IPCC AR5 SPM, 2014)

(C)

Projected Temperature Change



Solid Color

Very strong agreement

White Dots

Strong agreement

Gray

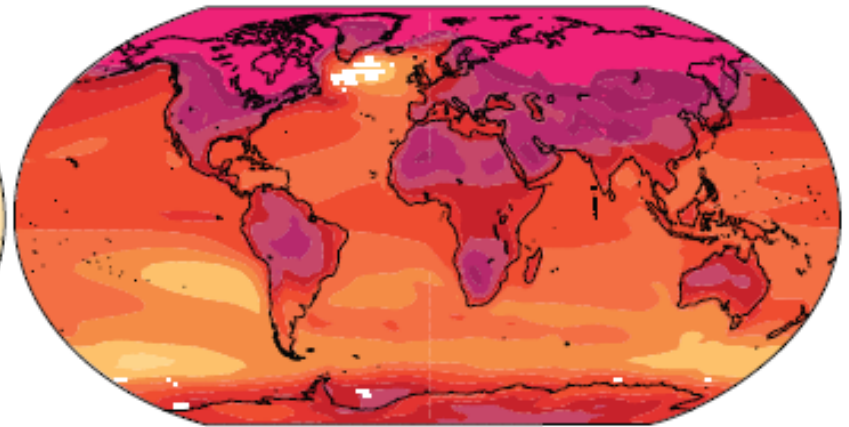
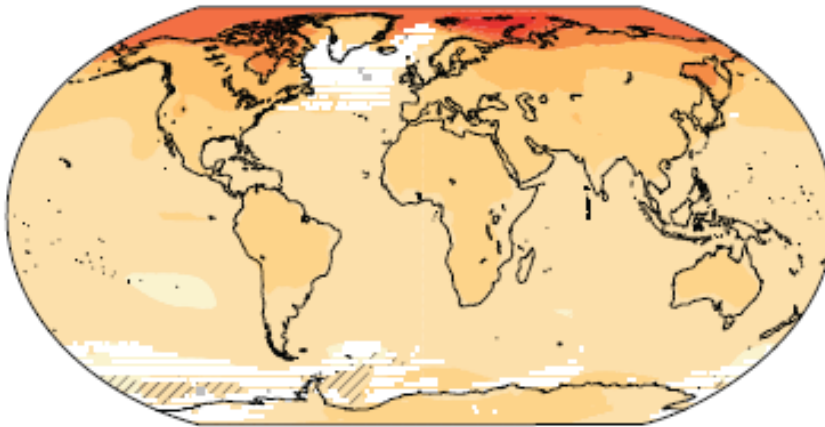
Divergent changes

Diagonal Lines

Little or no change

RCP2.6 2081–2100

RCP8.5 2081–2100



http://www.ipcc-wg2.gov/AR5/images/uploads/WG2AR5_SPM_FINAL.pdf

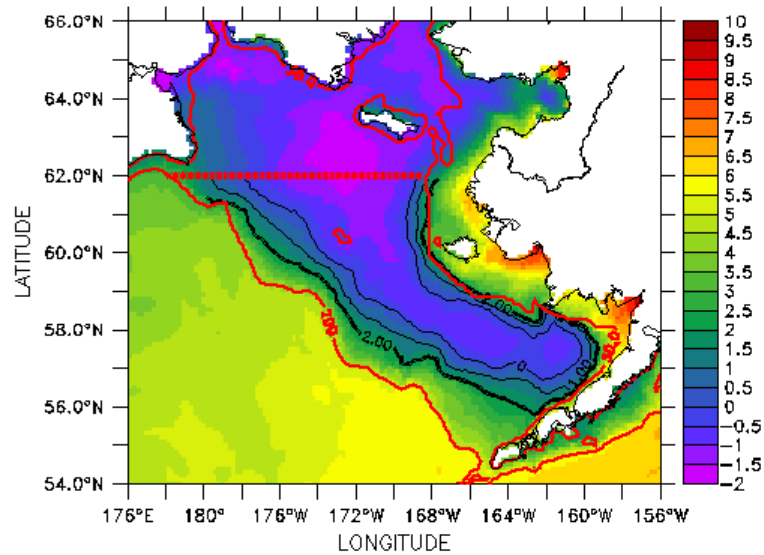


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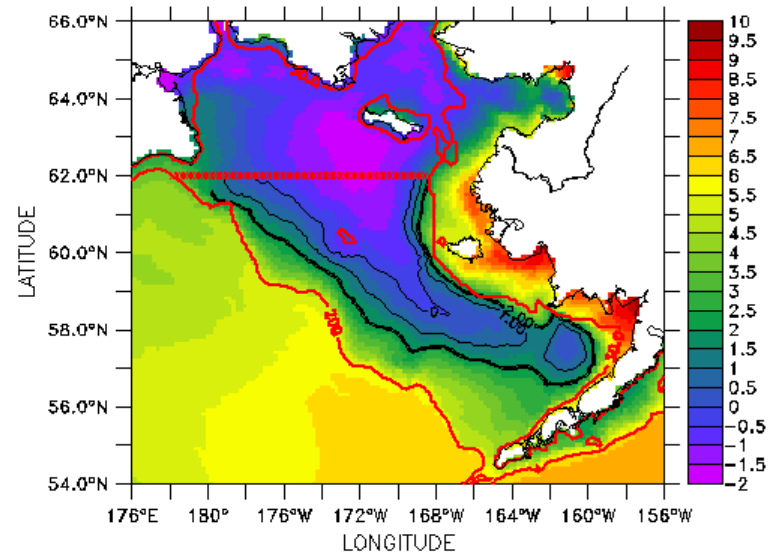
What do we expect in the Bering Sea and Arctic? – See IPCC WG 1

- **Increased ocean temperature**
- **Increased stratification of Arctic Ocean and the SE Bering Sea in summer**
- **Reduced sea ice extent in Arctic Ocean in summer**
- **Reduced winter sea ice extent and reduced cold pool extent in summer in the Bering Sea**
- **Changes in timing of sea ice breakup and set-up**
- **Changes in bio-chemical properties of Arctic Ocean and eastern Bering Sea (including ocean acidification)**
- **Changes in the size distribution and abundance of selected phytoplankton and zooplankton**

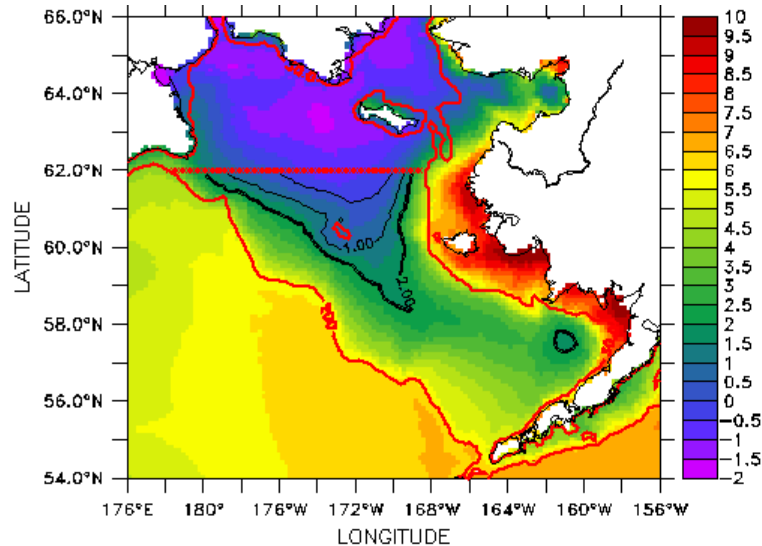
Projected EBS July bottom temperatures in SE Bering Sea (Al Hermann JISAO)



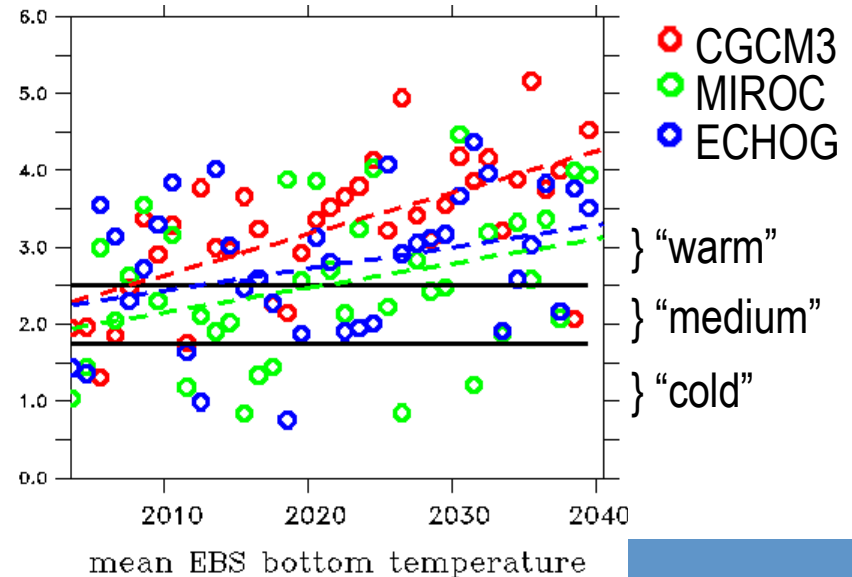
ensemble ave cold year



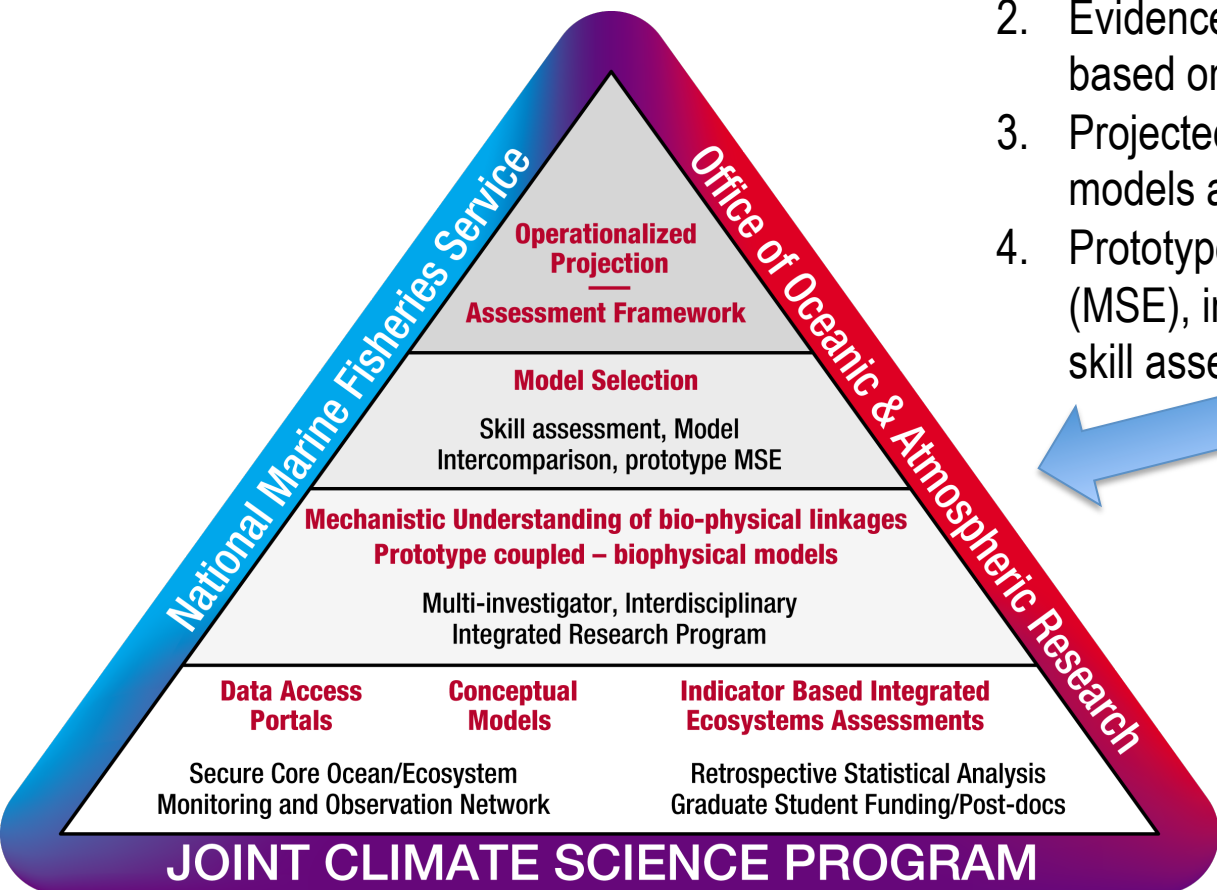
ensemble ave medium year



ensemble ave warm year



National Climate Assessment 2014



1. Vulnerability assessments
2. Evidence for past response and agreement based on literature
3. Projected response based on existing models and conceptual models
4. Prototype Management Strategy Evaluations (MSE), initial model inter-comparisons, and skill assessments

Deliverables listed in **RED**

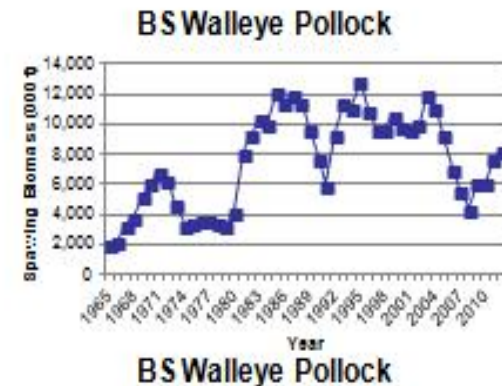
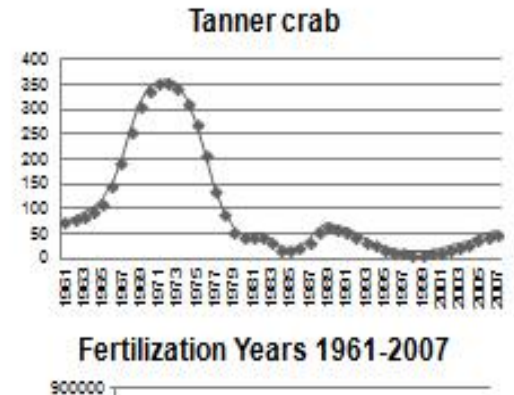
Funding request listed in **BLACK**



NOAA FISHERIES

What do we expect in the future? – Fish and Crab

- Shifts in spatial distribution of some stocks (IPCC WGII Chap 30; Poloczanska et al. 2013).
- Shifts in phenology of some stocks (match-mis-match).
- Shifts in production of some stocks (winners and losers).
- Some stocks may encounter habitats outside of current tolerances (esp. Ocean Acidification) (Pörtner 2010).
- Changing vital rates (growth, mortality, maturity schedules) (Neuheimer and GrønkJær 2012).
- Shifts in species interactions (predator-prey, competition).
- Cumulative effects may impact ecosystem structure and function in some regions.
- Changes will occur within an environment influenced by multiple stressors.
- Expect regional differences.



Ecosystem context: Larsen et al. 2014

- “The physical, biological, and socioeconomic impacts of climate change in the Arctic have to be seen in the context of often interconnected factors that include not only environmental changes caused by drivers other than climate change but also demography, culture, and economic development.”

Future Fisheries

- Demand for protein
 - World markets
- Range expansion to north uncertain
 - Infra-structure
- Bio-economic considerations (fuel, risk)
- Sustainable fisheries – Ecosystem Based Fisheries Management
 - International cooperation



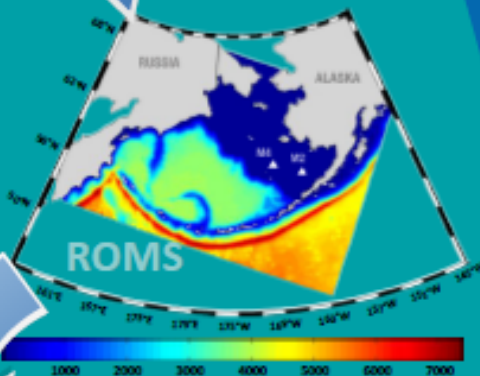
Photo Credit: Sam Zmolek, NOAA Fisheries. Photo of Dutch Harbor, Alaska

Earth System Models

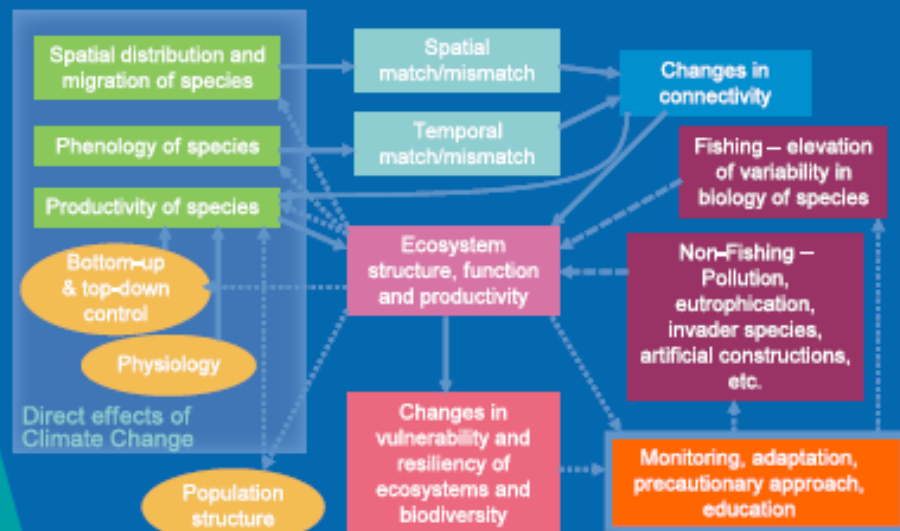


Regional Models

Dynamic Down-scaling



Dynamic Ecosystem Models



NPZ Model



Nutrients, Phytoplankton & Zooplankton Models

Multispecies projection model

Single species projection model

Individual Based Models

Spatial Ecosystem Models

Food-web models

Spatially Explicit Stock Projection Models

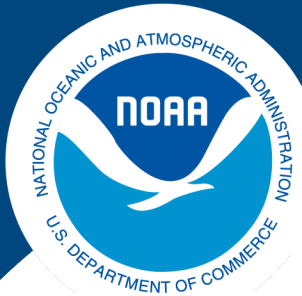
Size Spectra Models

Stock Projection Ensemble

2019 – Multi-model projections from common suite of climate scenarios for large marine ecosystems

- NMFS, ICES, PICES workshop April 2014 expected improvements to GCMs and Earth System Models.
- March 2015 3rd Effects of Climate Change on the World's Oceans Symposium
- August 2015 ICES/PICES workshop
 - Select suite of species/fisheries for assessment of fish and fishers response projections.
 - Select suite of future fishing scenarios (harvest strategies; aquaculture; market forces; capture technologies, technical interactions)
 - Select suites of models for comparative studies
 - Treatment of uncertainty – draw inference from simpler models?
 - Agree on strategies to address boundary issues



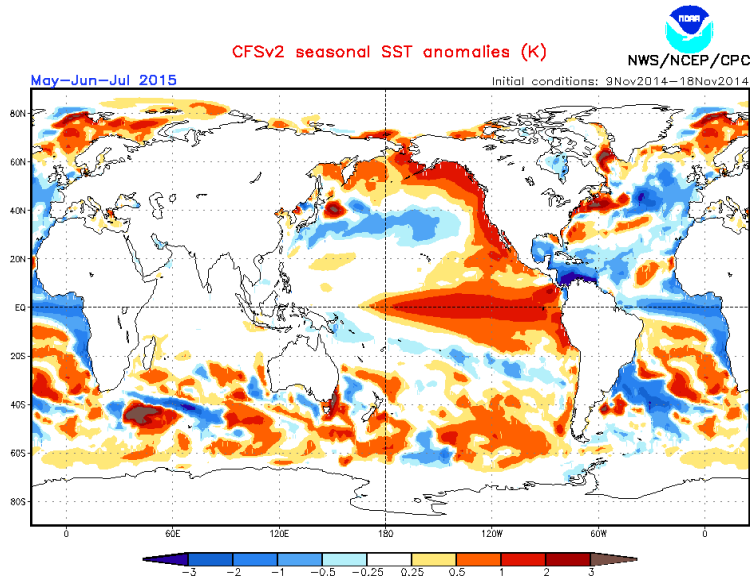


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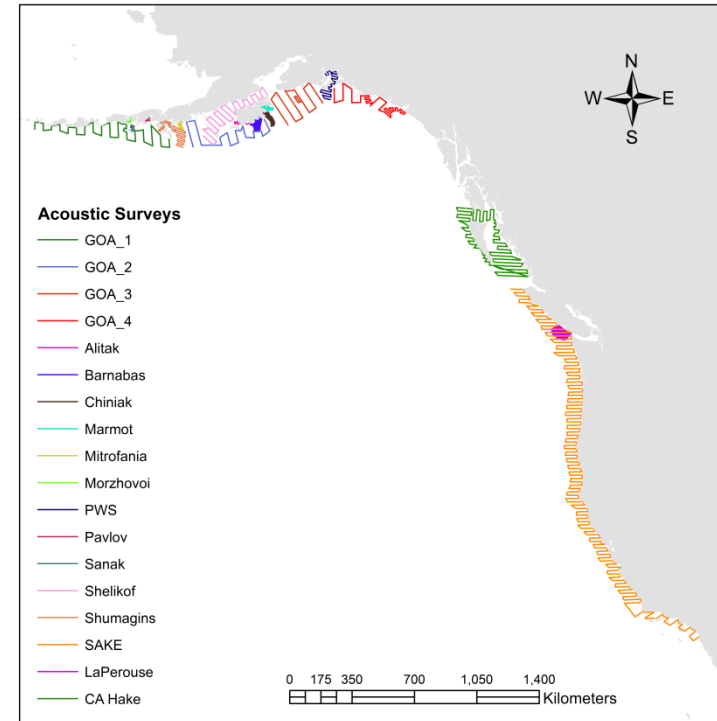
Summary

- **Within NOAA:** Prepare for next assessment cycle, strive to provide quantitative projections of climate impacts by 2019.
- **Within the US:** Strengthen collaborations between global ocean / climate modelers and fisheries modelers to develop agreed upon scenarios for quantitative projections. Provide multi-model approaches for 2019
- **Internationally:** Partner with international institutions to develop a coordinated projection modeling effort.
- **Within NOAA:** Use short-term ocean forecasts to enhance monitoring during anomalous events. Continue to explore and test mechanisms through short-term projections and skill assessment.

2014-2015 warm anomaly

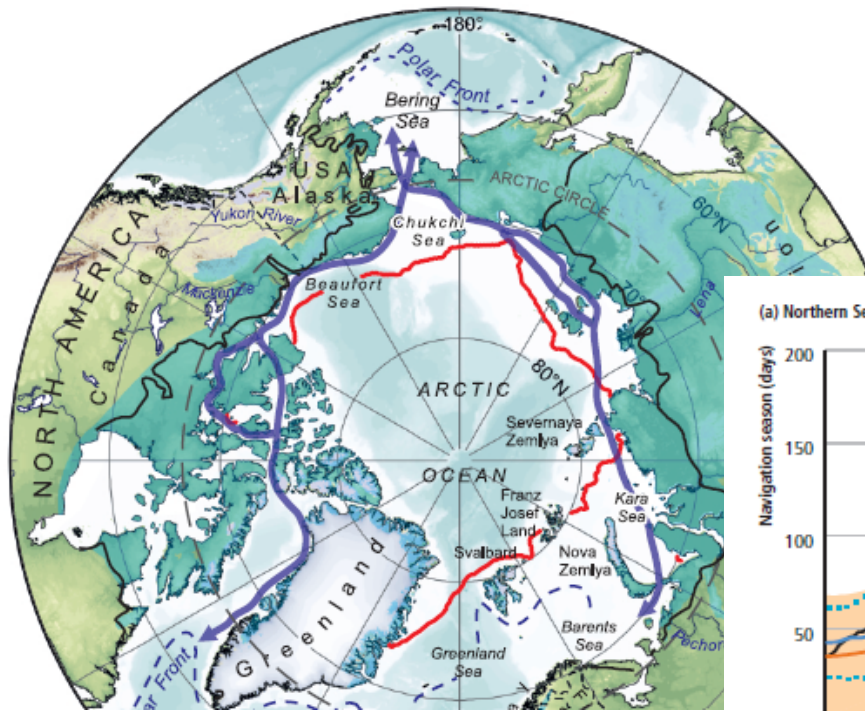


SST projection 2015 from NOAA's coupled forecast system (CFSv2)

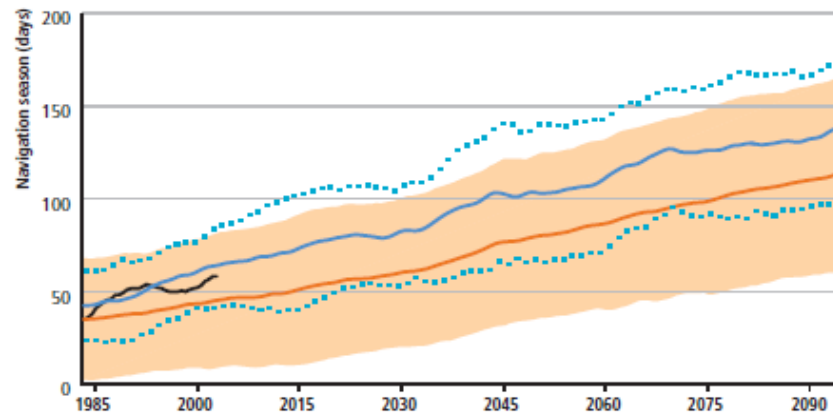


Approximate tracklines for 2015 U.S. and Canadian acoustic mid-water trawl surveys.

Arctic Sea Routes



(a) Northern Sea Route



(b) Northwest Passage

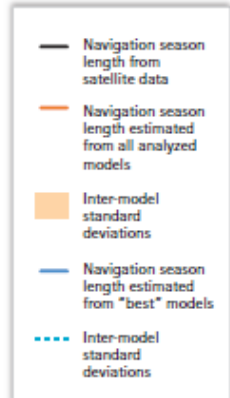
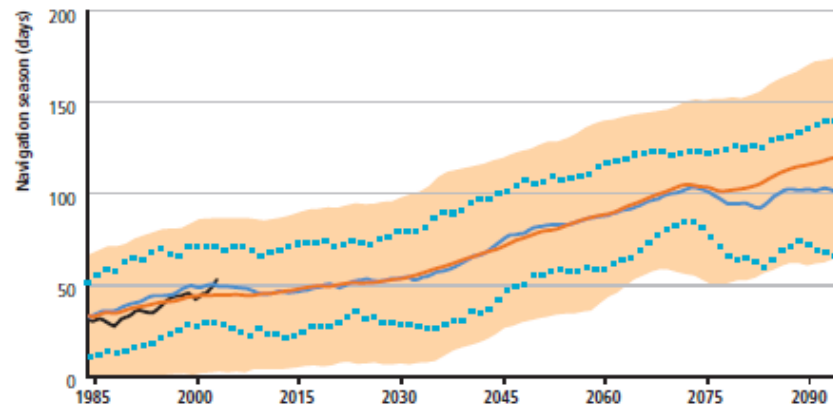


Figure 28-4 | Projected duration of the navigation period (days) over the Northwest Passage and Northern Sea Route (Khon et al., 2010).